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THE PSYCHOLOGY OF TIME.

BY HERBERT NICHOLS.

III.—EXPERIMENTS AT CLARK UNIVERSITY.

In October, 1889, I was requested by the instructor in Psychology at Clark University to investigate the apparently contradictory results obtained by various experimenters regarding the Constant Error of Time-judgments. As a preliminary, the methods of previous experimenters were tested, until after several weeks, a single, and perhaps crucial point seemed to stand out as the proper question upon which to concentrate investigation, namely, the effect upon our estimation of any particular interval of previous sustained exercise or practice upon some other interval. A long series of experiments was then regularly undertaken which lasted several hours daily, for a period of over nine months of actual experimental work. 27 persons were tested; over 500 "sittings," or series of reproductions were made, comprising a total of approximately 50000 single judgments recorded. Five lengths of interval were chiefly used, namely: .25, .50, .75, 1.25, 1.75, seconds.¹

Apparatus: After trying different metronomes in various ways, these were abandoned as inaccurate. Previous to beginning our regular experiments a nearly perfect instrument for beating time was found in a pendulum constructed as follows: A stiff bar, thin but wide, and five feet long, swung upon knife edges projecting from opposite sides a little above the middle of the length of the bar, and resting upon smooth metal plates, was supported by firm frame-work. Upon each end of the bar was a heavy 'bob' or weight which could be slid up or down and fastened with a spring and clamp-screw at any distance from the point of support. With the first pendulum made, any length of interval could

¹ As before, the unit throughout this section is one second, except where specifically stated to the contrary.

be obtained, by proper adjustment, from half a second to two seconds, beyond which, beats could be regularly omitted from the electric circuit to be described, thus securing intervals of any length desired. The lower end of the pendulum-rod bore a platinum needle that at each swing made electric connection, at the centre of the pendulum arc, with a mercury meniscus. This pendulum, once set in full swing by the hand, would, for medium-length intervals, preserve regular beats for a far longer time than any single set of experiments, without any discoverable variation whatever. Great care was taken at each change of the interval to adjust the 'bobs' and mercury contact so as both to make the interval of exactly the stated length, and the back and forth swings precisely equal, these being the two matters needing the nicest adjustment in all pendulum motion. The pendulum was introduced into the same electric circuit with an ordinary telegraph key, a telegraph sounder, and a Deprez signal which wrote on the drum of a Ludwig kymograph with automatic spiral thread for the revolving drum. Another Deprez signal wrote the vibrations of a tuning fork upon the same drum, by means of a separate circuit and a König contact. For adjusting the intervals and beats for the first time, a fork of 100 double vibrations was used; the adjustment was extended through one hour, until a beat was secured, the sum of whose error was indistinguishable for that space of time, and therefore the error for any set of experiments practically zero. Two other pendulums were also made for shorter intervals, one of them giving quarter seconds. Any two of these pendulums could be introduced into different loops of the same circuit, and each being adjusted to a different interval, either of the intervals could by means of a bridge, be sent through the same sounder at the will of the operator and without stopping either pendulum; or again at will both pendulums could be cut out of the circuit altogether. The reproductions or judgments of the person undergoing experimentation were expressed by a slight movement of the finger upon an electric key that, by another Deprez signal in a separate circuit, recorded the judgment upon the kymograph drum. Thus during each set of experiments three electric signals with points arranged

over one another, precisely in the same line at right-angles to the motion of the drum, continuously wrote their separate records as follows: Number one recorded the vibrations of a tuning-fork; number two, the beats of whichever length of interval the subject was hearing from the pendulum sounder; and number three, the judgments of this interval expressed by the subject. The tracings on the drum were "fixed" and preserved.

As above stated the length of the reproduction was measured by tuning-fork vibrations written upon the drum; for all the experiments except those of table E, a fork was used making 50 double vibrations per second, thus recording hundredths of a second; for table E, which concerns intervals longer than the others (1.75), a fork of 25 double vibrations, recording fiftieths of a second was used. Many methods were tried for saving the enormous labor of counting these vibrations, which task, together with its strain upon the eyes for such a long series of experiments as the present, can only be appreciated by one who has tried it for several months. The slightly irregular motions of the kymograph make it entirely inaccurate merely to scale the intervals. The quickest and safest method of counting we discovered was as follows: When the paper is cut from the drum it presents on the sheet several parallel lines. Several scales were made fitting all the degrees of irregularity which the fork vibrations in these lines from time to time displayed; one of these scales was then selected to fit each line, part of a line, or set of lines according to their variation; usually three, and often one scale would fit the fork-record of a whole sheet; the eye quickly detects, after some experience, whether the scale fits or not, and thus enables the counting of the vibrations by using the scale as a tally, with comparative facility and absolute accuracy.

It is an important feature that in all experiments to be reported, great pains was taken to keep the persons experimented upon, in entire ignorance of the character of their judgments, or of any of the 'points' or the nature of the experiments whatever, in order to secure absolute freedom from unconscious prepossessions or subjective influences; where

this was not accomplished, as was necessarily the case in two instances, (subjects S. and L.), there was from the character of the men a minimum probability of subjective prepossessions. Moreover as by far the greater majority of the subjects were thus precluded from prepossession until their tests were completed, and as the records of the few who were not so precluded, including those upon myself, entirely accord with those who were, we think the results are reasonably free from this too usually neglected source of vitiation.

Method: The first class of experiments was conducted as follows: The subject was always seated alone in a noiseless room; the electric sounder and the recording key, both on a table before him, were the only apparatus within his sight or hearing; the former brought him through one circuit the beats of the metronome in sharp metallic strokes of uniform strength; with the latter he recorded his judgments upon the kymograph drum in another room. In the latter room with the kymograph was also the pendulum and remaining apparatus, presided over by an assistant. The precise method of these A experiments was invariably as follows: (1) The pendulum was started with full swing, giving beats .75 in length, the electric circuit remaining open. (2) "Ready" signals passed between assistant and subject. (3) Kymograph and tuning-fork were started. (4) The assistant closed the pendulum circuit long enough to send to the subject six beats, or five intervals of .75 each. (5) The assistant opened the pendulum circuit, silencing the sounder. (6) The subject meantime had sought to catch the beat of the sounder from the first beat of the norm and simultaneously to reproduce the beat upon his recording key during the 6 beats of the norm. After the sounder ceased, he continued to reproduce the interval, without breaking the continuity of the series, according to his closest judgment, these reproductions being recorded continuously by the proper circuit upon the drum. (7) The assistant permitted the subject to continue his reproductions until the drum had exhausted the full length of its spiral, when he signalled "stop." The drum was set to exhaust its spiral in two minutes; thus through all classes of experiments to be reported, the reproductions were extended through approx-

imately the same space of time, though of course the number of reproductions varied according to the length of the intervals used and the judgments made. Frequently short portions of the spiral would be used in adjustments of the signals or by accidents, so that the time actually used was shortened more or less. (8) After a few moments of rest a new beat, .9 long, or 20% longer than the norm was sent in to the subject, which with closest possible attention and care he strove to reproduce simultaneously, stroke exactly with stroke, during three minutes. No record was made on the drum of this exercise or practice. (9) A fresh drum having been put in the kymograph by the assistant during the above exercise, immediately upon the expiration of the three minutes, a signal was given to the subject to cease practicing. (10) A new series of 6 beats of the original norm of .75 was then given, and the above numbers (1) to (7) inclusive were repeated precisely as in their first order. In other words a new drum-full of reproductions of the .75 was obtained under precisely the same conditions as the first, with the exception that the first series was "Without practice" or exercise upon any particular interval, while the second set was under the immediate influence of 3 min. practice upon an interval 20 per cent. longer, *i. e.* on .9 (11) After a proper rest, still a third series or drum-full was taken precisely as before, except this time after like practice upon an interval 20 per cent. shorter than the norm, that is on .6

Thus was obtained at each "sitting," though with proper rest between each series, three sets of judgments, as follows : (a) without practice ; (b) after 3 min. exercise upon .9 intervals ; (c) after 3 min. exercise upon .6 intervals. Table A is arranged to show the comparative results of these three sets.

TABLE A.¹

Norm, .75 sec. Practice, 3 min. each on .9 sec. and .6 sec. (20 per cent. longer and shorter). Trials, 17. Persons, 6.

(0), (+) and (—) indicate average reproductions made after hearing 6 beats, separated by a normal interval of .75 sec. (0) indicates averages made without practice ; (+) after 3 min. practice on 9 sec. ; (—) after 3 min. practice on .6. Where the (+) figure is greater than the corresponding (0) figure or the (—) less than the corresponding (0),

¹ The exigencies of space in the JOURNAL require the withholding of still more detailed tables carefully prepared and in the author's possession.

the figures are printed heavy, to show that these figures follow the rule that practice on a longer interval lengthens the judgment and practice on a shorter interval shortens the judgment as expressed in a following effort to reproduce the standard interval. The letters heading the vertical columns are the initials of persons acting as subjects. The small figures under each initial give the number of experiments from which the averages are made.

Set.	S. 5	L. 3	C. 3	F. 3	A. 2	N. 1	General Averages 17
(0)	.712	.607	.750	.735	.671	.814	.712
(+)	.710	.663	.727	.757	.749	.801	.723
(—)	.715	.614	.697	.706	.680	.731	.689

Results: With normal interval of .75, the general average of 17 tests upon 6 persons shows that there is a very slight and uncertain tendency to follow the rule that three minutes previous close attention to, and simultaneous reproduction of, intervals respectively 20% longer or shorter than the norm, correspondingly lengthen or shorten the judgment; that is, that the habit formed by the practice holds over to influence the succeeding judgments but slightly, if at all.

Series A being deemed inconclusive, it was followed by Series B, the only changes made being first, that a norm of 1.25 was used in place of .75, and second, that only two sets of reproductions were taken, namely: one without practice (0) and one after three minutes practice (—) on an interval of .25.

TABLE B.

Norm, 1.25 sec. Practice, 3 min. on .25 sec. Trials, 60. Persons, 12. At the head of each vertical double column is the initial of the subject. In the left hand column are the numbers of the single experiments from which the averages in the other columns are computed. The columns headed (0) contain average judgments of the 1.25 norm made without practice; those headed (—) similar judgments made after three minutes practice on a .25 beat. This table shows the average for each set of each individual, and also the general averages of each individual and of the total experiments of this table. The averages for this table are computed from the full number of reproductions of each drumful.

No. of Trial.	N.		S.		C.		L.		F.		A.	
	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)
1	1.423	1.328	1.332	1.275	1.244	1.146	1.245	1.166	1.597	1.517	1.138	1.212
2	1.453	1.303	1.470	1.403	1.229	1.169	1.238	1.091	1.437	1.425	1.379	1.319
3	1.530	1.317	1.748	1.343	1.278	1.276	1.222	1.258	1.491	1.446	1.368	1.349
4	1.321	1.252	1.313	1.306	1.316	1.307						
5	1.376	1.248	1.493	1.176	1.281	1.253						
6	1.333	1.287	1.519	1.328	1.335	1.280						
7	1.278	1.252	1.625	1.550	1.323	1.267						
8	1.249	1.189	1.515	1.522	1.334	1.307						
9	1.234	1.216	1.282	1.156	1.437	1.312						
10	1.346	1.277	1.226	1.209								
11	1.285	1.229										
12	1.336	1.185										
13	1.245	1.209										
14	1.350	1.196										
15	1.396	1.164										
16	1.337	1.265										
17	1.278	1.198										
18	1.296	1.186										
19	1.362	1.257										
20	1.381	1.287										
Gen'l Average.	1.335	1.242	1.435	1.313	1.306	1.253	1.236	1.167	1.506	1.461	1.291	1.290
Difference.	-.092		-.121		-.053		-.068		-.044		-.001	

TABLE B.—Continued.

No. of Trial.	W.		M.		Sh.		K.		Ca.		D.	
	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)	(0)	(—)
1	1.137	1.201	1.169	1.189	1.352	1.275	1.311	1.280	1.138	1.118	1.441	1.288
2	1.355	1.284	1.239	1.206	1.147	1.216	1.256	1.245	1.146	.954		
3	1.246	1.199										
Gen'l Average.	1.246	1.226	1.203	1.192	1.242	1.241	1.284	1.261	1.142	1.022	1.441	1.288
Difference.	-.020		-.011		-.001		-.023		-.120		-.534	

Results: Total General Average Without Practice, 1.3228"

“ “ “ After “ 1.2533"

Difference, .0695"

These B experiments upon the 1.25 interval, show an

almost universal shortening of those judgments which were preceded by three minutes close attention to, and simultaneous reproduction of, beats .25 long, the average difference between the judgments of the two conditions being .0695. The average difference of no individual out of the 12 included in the table varied from the general rule, and only in 6 trials out of the 60 was the rule broken for single trials, and no person broke the rule more than once. In general, those most experienced in laboratory work conformed most strictly to the usual law; the law was most frequently broken upon the first test made upon an individual, this happening 4 times out of the 6; and it may be remarked in relation herewith, that more variations should be looked for from nervousness or other disturbing causes under these conditions, and from those persons with whom they were actually found. In general, also, the amounts of the difference made between (0) and (—) was proportional to the amount of experience the subject had in psychophysical experiment; for instance, those for Dr. Donaldson, Dr. Sanford, Dr. Lombard and myself are among the largest. Curves were drawn for each individual similar to those of the accompanying chart. Study of these discovers that the Constant Error, whether plus or minus, shows itself most frequently to a marked degree, from the very beginning of the reproductions, and nearly always so before the seventh to the ninth beat, or in other words, before the elapse of ten seconds. Also, the Constant Error tends to preserve a uniform course from the beginning, either the judgments growing gradually longer or gradually shorter throughout the drum, according as their value is greater or less than the normal; in those individuals where the Constant Error is greatest and most marked, this gradual increase or decrease is most marked, as with Dr. Donaldson, where is the largest plus value, and with Dr. Lombard, where is next to the greatest minus value of the judgments.

A beat .25 in length was now chosen for the norm, and being shorter and more difficult to catch was always given 10 times as a sample for each set of reproductions, in place of 6 beats, as in the previous experiments. The practice interval was also changed for this table to 1.25, and for a period

of 5 minutes in place of 3 minutes, as formerly. The reason for this increase in the length of the time of practice is manifest when we consider that two factors enter into the functions of practice, namely: first, the number of repetitions which the subject or central cells would be called upon to make during the practice; and secondly the fatigue, nutritive, restorative, or other processes, which may depend somewhat upon the mere length of time which the practice is continued. We know little or nothing of the effects of either factor, but as in the C experiments practice on 1.25" gave much fewer number of repetitions, the length of practice time was increased from 3 to 5 minutes, which was an indefinite compromise between proportional length of time of practice, and proportional number of beats.

The shortness of the interval would have given a great number of reproductions, since the same length of the drum's spiral was used as before; and the labor of counting so many would have been excessive; therefore, although the subject made his reproductions for approximately the same length of time as in the previous experiments, records were taken upon the kymograph of only the first 40 reproductions, and of a second set of 40, taken after the lapse of one minute from the last beat of the norm. All the other conditions were the same as before, making the method for Table C as follows: (1) Norm of .25 (10 beats given); a drumful of reproductions taken without practice. (2) Practice 5 minutes on 1.25 beats. (3) Norm of .25, (10 beats given); a drumful of reproductions taken after practice.

TABLE C.

Norm, .25 sec. Practice, 5 min. on 1.25 sec. Trials, 30, Persons, 8.

Shows averages of each set and trial, of each individual, and the general averages as before. Averages of the first 40 reproductions are marked *a*, of the second 40, *b*; and the average of *a* and *b* is marked *c*; (0) without practice; (+) after 5 min. practice on 1.25.

No. of Trial.	S.		N.		H.		Ma.	
	(0)	(+)	(0)	(+)	(0)	(+)	(0)	(+)
1	a	.259	.289	.238	.241	.273	.239	.249
	b	.245	.283	.230	.243	.232	.297	.242
	c	.252	.283	.234	.242	.252	.293	.245
2	a	.254	.255	.247	.248	.244	.262	.246
	b	.239	.250	.243	.247	.225	.262	.238
	c	.246	.253	.245	.247	.235	.262	.242
3	a	.249	.251	.256	.248	.242	.259	
	b	.244	.244	.245	.242	.227	.251	
	c	.246	.247	.251	.245	.234	.255	
4	a	.261	.260	.237	.239			
	b	.243	.255	.234	.240			
	c	.252	.257	.235	.240			
5	a	.263	.265	.242	.252			
	b	.258	.255	.234	.248			
	c	.260	.260	.238	.250			
6	a	.259	.263	.246	.254			
	b	.254	.253	.238	.250			
	c	.256	.253	.242	.252			
7	a	.249	.265	.254	.261			
	b	.236	.262	.254	.259			
	c	.242	.264	.254	.260			
8	a	.253	.247	.242	.248			
	b	.256	.248	.217	.234			
	c	.255	.244	.230	.241			
9	a	.249	.246	.237	.246			
	b	.234	.245	.208	.237			
	c	.242	.246	.222	.241			
10	a	.245	.251	.243	.254			
	b	.234	.254	.231	.251			
	c	.239	.252	.227	.252			
Totals.	a	.254	.259	.244	.249	.253	.270	.248
	b	.254	.255	.233	.245	.228	.270	.240
	c	.249	.257	.239	.247	2.40	.270	.244
Differ-ences.	a		.005		.017			.006
	b		.011		.011			.006
	c		+.008		+.029			+.006

TABLE C.—Continued.

No. of Trials.	Ca.		B.		McD.		T.	
	(0)	(+)	(0)	(+)	(0)	(+)	(0)	+
1 {	a	.244	.252	.255	.253	.248	.258	.252
	b	.233	.253	.246	.250	.251	.256	.245
	c	.238	.253	.250	.252	.250	.257	.249
2 {	a	.246	.251					
	b	.250	.254					
	c	.248	.252					
Totals. {	a	.245	.251	.255	.253	.248	.258	.252
	b	.241	.253	.246	.250	.251	.256	.245
	c	.243	.252	.250	.252	.250	.257	.249
Differ- ences. {	a		.006	.001		.000		.006
	b		.012	.004		.000		.011
	c		+.009	+.002		+.000		-.008

Results: Total General Average Without Practice (*a*) .2500; (*b*) .2396; (*c*) .2448.

Total General Average After Practice (*a*) .2557;
(*b*) .2525; (*c*) .2542.

Difference (*a*) .0057; (*b*) .0129; (*c*) .0093.

These C Experiments seem to show that 5 minutes' practice upon a 1.25 beat, lengthens judgments of .25 intervals on an average .00935; the result is the more striking and conclusive when the smallness of the average lengthening is compared with its constancy, the "after practice" set of General Averages of the total 30 trials, exceeding the "without practice" set in every instance, and even in averages of three trials, as those of H (a subject who at the time was entirely ignorant of the purpose of his experiments), the "after practice" judgments falling below the corresponding "withouts" but twice out of the 240 recorded judgments. The Curves of the General Averages of the total thirty trials is shown in Fig. III of the Chart, and those of H in Fig. IV. The continuous line in the chart shows the judgments "without practice," and the dotted line "after practice" as previously in Figs. I and II.

TABLE D.

Norm, .75 sec. Practice, 7 min. on 1.75 sec. and 5 min. on .25. Trials, 30. Persons, 8.

This table will be understood without other explanation than that its method was precisely that of Table A, except that the 'long' practice was changed from 3 min. upon .9 to 7 min. upon 1.75, and the 'short' practice from 3 min. upon .6 to 5 min. upon .25; also, 7 beats of the norm were given for the copy from which the reproduction of each set was made. The table shows averages of each set and trial, of each individual, and the General Averages as before. Averages of the first 40 reproductions are marked *a*, of the second 40 *b*, and the average of *a* plus *b* is marked *c*; (0) = without practice; (+) after 7 min. practice on 1.75; (—) = after 5 min. practice on .25.

		S.			N.			H.			B.		
No. of Sittings.		(0)	(+)	(-)	(0)	(+)	(-)	(0)	(+)	(-)	(0)	(+)	(-)
1	a	.725	.786	.710	.801	.803	.747	.798	.764	.666	.705	.685	.648
	b	.726	.788	.690	.800	.814	.759	.835	.869	.670	.629	.621	.599
	c	.725	.787	.700	.800	.808	.753	.817	.817	.668	.667	.653	.623
2	a	.748	.835	.772	.781	.771	.751	.800	.878	.744			
	b	.766	.882	.792	.773	.798	.761	.899	.963	.794			
	c	.757	.859	.782	.777	.785	.756	.849	.920	.769			
3	a	.793	.795	.699	.739	.846	.712	.810	.982	.774			
	b	.801	.803	.718	.753	.844	.722	.894	1.148	.900			
	c	.797	.799	.709	.746	.845	.717	.852	1.065	.837			
4	a	.718	.795	.721	.736	.836	.696	.732	.909	.732			
	b	.699	.809	.754	.731	.975	.676	.794	1.056	.779			
	c	.708	.802	.737	.734	.906	.686	.763	.985	.755			
5	a	.768	.924	.727	.822	.826	.740	.787	1.003	.736			
	b	.746	1.019	.729	.790	.889	.716	.833	1.233	.794			
	c	.757	.971	.728	.806	.857	.728	.810	1.118	.765			
6	a	.782	.877	.735	.777	.804	.709						
	b	.761	1.120	.705	.775	.810	.704						
	c	.772	.999	.720	.776	.807	.707						
7	a	.781	.889	.778	.771	.820	.708						
	b	.824	1.118	.819	.770	.990	.693						
	c	.803	1.003	.798	.770	.905	.701						
8	a	.714	.816	.716	.761	.972	.722						
	b	.704	.822	.696	.798	.997	.727						
	c	.709	.819	.706	.780	.984	.725						
9	a	.758	.879	.744	.753	.961	.741						
	b	.768	.852	.743	.758	.952	.735						
	c	.764	.865	.743	.756	.956	.738						
10	a	.754	.840	.726	.747	.819	.788						
	b	.780	.855	.716	.751	.867	.777						
	c	.767	.847	.721	.749	.843	.782						
Totals.	a	.754	.843	.732	.768	.845	.731	.785	.907	.730	.705	.685	.648
	b	.757	.907	.736	.769	.893	.727	.851	1.053	.787	.629	.621	.599
	c	.755	.875	.734	.767	.869	.729	.818	.980	.758	.667	.653	.623
Differ- ences.	a		+.089	-.021		+.076	-.037		+.121	-.055		-.020	-.057
	b		+.149	-.019		+.123	-.042		+.202	-.064		-.008	-.030
	c		+.119	-.021		+.100	-.040		+.162	-.059		-.014	-.044

TABLE D.—Continued.

No. of Sittings.	McA.			Ma.			Sh.			Ca.		
	(0)	(+)	(—)	(0)	(+)	(—)	(0)	(+)	(—)	(0)	(+)	(—)
1 { a b c	.743	.739	.699	.695	.734	.641	.759	.835	.713	.702	.734	.679
	.708	.731	.635	.624	.708	.688	.731	.892	.720	.644	.687	.553
	.725	.735	.667	.659	.721	.665	.740	.863	.716	.673	.711	.616
Totals. { a b c	.743	.739	.699	.695	.734	.641	.759	.835	.713	.702	.734	.679
	.708	.731	.635	.624	.708	.688	.731	.892	.720	.644	.687	.553
	.725	.735	.667	.659	.721	.665	.740	.863	.716	.673	.711	.616
Differ- ences. { a b c		-.004	-.044		+.039	-.054		+.076	-.122		+.032	-.023
		+.023	-.073		+.084	+.064		+.161	-.011		+.043	-.091
		.010	.058		+.062	+.006		+.123	.024		+.038	.057
General Average of All.						Totals. { a b c	.758 .762 .760	.838 .897 .867	.722 .725 .724			
						Differ- ences. { a b c		+.080 +.134 +.107	-.035 -.036 -.036			

Results: Total General Averages Without Practice (a) .7583; (b) .7621; (c) .7602.

Total General Averages after practice on longer beat (a) .8385; (b) .8971; (c) .8678.

Total General Averages after practice on shorter beat (a) .7225; (b) .7255; (c) .7240.

Total General Average Difference after practice on longer beat (a) .0802; (b) .1349; (c) .1075.

Total General Average Difference after practice on shorter beat (a) .0358; (b) .0366; (c) .0362.

Comparison of experiments *A* and *D* shows that, for the same interval of .75, while in the former with a difference of 20 per cent. between the norm and practice intervals the effect of habit or practice was so slight as to be uncertain if active at all, in the latter experiments, with a much greater difference between the norm and practice intervals, the effect

was strong and constant. Figure V of the chart shows the curve of the General Averages for the 30 trials and 8 persons; figure VI shows the curve for Sh., and illustrates a single trial.

TABLE E.

Norm, .5 sec. Practice, 5 min. on 1.75 sec. Trials, 6. Persons, 2.

The only other variation than those in the above line was for these experiments, that 10 beats of the norm were given for the sample from which each set of reproductions was made. Averages of the first 40 reproductions are marked *a*, of the second 40, *b*; the averages of *a* plus *b* are marked *c*; (0) = Without Practice; (+) = after 5 min. practice on 1.75.

No. of Trials.	S.		N.	
	(0)	(+)	(0)	(+)
1 { <i>a</i>	.517	.541	.491	.521
{ <i>b</i>	.503	.518	.484	.515
{ <i>c</i>	.510	.530	.487	.519
2 { <i>a</i>	.491	.528	.503	.523
{ <i>b</i>	.505	.559	.483	.516
{ <i>c</i>	.498	.544	.493	.520
3 { <i>a</i>	.497	.535	.489	.498
{ <i>b</i>	.504	.551	.484	.477
{ <i>c</i>	.500	.543	.487	.487
Totals. { <i>a</i>	.501	.534	.494	.514
{ <i>b</i>	.503	.542	.466	.502
{ <i>c</i>	.502	.538	.480	.508
Differences.	+.033 +.039 +.036		+.020 +.035 +.028	

Results: Total General Averages Without Practice (*a*) .4980; (*b*) .4852; (*c*) .4916.

Total General Averages after practice on longer beat (*a*) .5246; (*b*) .5228; (*c*) .5237.

Total General Average difference (*a*) .0266; (*b*) .0376; (*c*) .0321.

Figure VII of the chart shows the curve for the general averages of the six tests of these experiments on the interval .5.

TABLE F.

Norm, 1.75. Practice 6 min. on .5. Trials, 6. Persons, 2.
 Seven beats of norm given for sample to be reproduced. (0) =
 Without Practice; (—) = after 6 min. practice on, .5 sec.

No. of Trials.	S.		N.	
	(0)	(—)	(0)	(—)
1	2.03	2.14	2.19	1.83
2	2.06	2.36	2.24	1.79
3	2.31	2.35	1.88	1.75
Totals.	2.136	2.284	2.049	1.790
Difference.	+.048		— .259	

Results: Total General Average Without Practice, 2.089

“ “ “ After “ 2.010

“ “ “ Difference, — .079

It will be observed that the three trials of S. for this interval are all contrary to the usual law; whether this is accidental and due to the small number of the trials, or if practice is less efficient in its influence upon judgments of long intervals, is undetermined; we incline to believe the former.

At this point in the experiments it appeared conclusive that a certain amount of sustained exercise, with close attention to the repetition of definite beats heard from a pendulum or sounder, and reproduced by motion of the finger upon a key, induces some sort of more or less permanent effect or habit, whose influence unconsciously modifies accordingly the judgments or reproductions of other beats heard and reproduced immediately after such exercise or practice. The question now arose whether this effect was muscular or “central.” To determine this, the following experiments were instituted; their method was the same as the foregoing except that in place of hearing the beats of the sounder the

armature or stroke-bar of the latter was pressed lightly between the thumb and forefinger of the *left* hand; the soft parts of the balls of the fingers were intruded slightly between the bar and the anvil or brasses between which the bar played, and, the circuit being closed, each time the pendulum made a stroke a "pulse-like" sensation was felt by the fingers. The left hand, thus holding the sounder, was then rolled in several thicknesses of cloth and folded with a woollen coat, and the ears closed with cotton or wax till no noise from the sounder could be heard with the closest possible attention. Also, the practice was now exercised or received in a purely afferent manner, without repeating the practice interval upon the key, simultaneously with the beats of the sounder as was done in the other experiments. By these means the effect of the practice was confined afferently to the left thumb and forefinger, and to their respective nervous centres. The reproductions of the trial intervals, both the set previous to practice and the correlative set after practice, were made with the right hand or fingers, as in all previous experiments.

It is evident that if similar effects from practice should manifest themselves under these conditions as in the former experiments, the cause could in no way be attributed to a muscular habit, because no muscles were at all concerned in the reproductions of the normal or trial intervals, which had been in any way influenced by the previous afferent exercise on the practice interval. Of course it is possible that every afferent impulse occasions some efferent discharge, although the same be actively ineffectual; yet even if this did happen, we think it would be fair to assume that the cause of the difference between the two sets of judgments was central and not muscular.

TABLE G.

Norm, 1.25. Practice, 6 min. on .25. Trials, 50. Persons, 16.

Practice taken by touch alone in left thumb and finger, the beat being inaudible. Ten beats of norm given as sample for all reproductions. (A) = Averages without practice; (B) = Averages after 6 min. practice on .25 beats; D = difference between (A) and (B).

TABLE G.

No. of Sittings.	S.	N.	L.	H.	C.	A.	D.	B.
1 { <i>A</i>	1.276	1.200	1.065	1.480	1.339	1.146	1.433	1.442
<i>B</i>	<u>1.215</u>	<u>1.109</u>	<u>.942</u>	1.530	1.390	<u>1.111</u>	1.437	<u>1.334</u>
<i>D</i>	— .061	— .091	— .123	+ .050	+ .051	— .035	+ .004	— .108
2 { <i>A</i>	1.302	1.174	1.025	1.443	1.564	1.396		
<i>B</i>	<u>1.202</u>	<u>1.033</u>	1.238	<u>1.410</u>	<u>1.475</u>	<u>1.393</u>		
<i>D</i>	— .100	— .141	.203	.033	— .089	— .003		
3 { <i>A</i>	1.247	1.140	1.358	1.447	1.289	1.446		
<i>B</i>	<u>1.195</u>	<u>1.029</u>	<u>1.159</u>	<u>1.282</u>	1.438	1.480		
<i>D</i>	— .052	— .111	— .199	— .165	+ .149	+ .034		
4 { <i>A</i>	1.207	1.082	.883	1.388	1.307	1.493		
<i>B</i>	1.350	<u>1.058</u>	<u>.882</u>	<u>1.223</u>	<u>1.255</u>	<u>1.420</u>		
<i>D</i>	+ .043	— .024	— .001	— .165	— .052	— .073		
5 { <i>A</i>	1.390	1.245	1.093	1.333	1.277	1.553		
<i>B</i>	<u>1.281</u>	<u>1.071</u>	<u>1.012</u>	<u>1.233</u>	1.284	<u>1.369</u>		
<i>D</i>	— .109	— .174	— .081	— .100	+ .007	— .184		
6 { <i>A</i>	1.174	1.179						
<i>B</i>	<u>1.109</u>	<u>1.085</u>						
<i>D</i>	— .065	.094						
7 { <i>A</i>	1.350	1.326						
<i>B</i>	1.353	<u>1.202</u>						
<i>D</i>	+ .003	— .124						
8 { <i>A</i>	1.322	1.261						
<i>B</i>	<u>1.289</u>	<u>1.089</u>						
<i>D</i>	— .033	— .172						
9 { <i>A</i>	1.583	1.271						
<i>B</i>	<u>1.335</u>	<u>1.154</u>						
<i>D</i>	— .248	— .117						
10 { <i>A</i>	1.334	1.213						
<i>B</i>	1.361	<u>1.031</u>						
<i>D</i>	+ .027	— .182						
Totals. { <i>A</i>	1.310	1.210	1.061	1.416	1.347	1.389	1.433	1.442
<i>B</i>	<u>1.262</u>	<u>1.083</u>	<u>1.029</u>	<u>1.326</u>	1.363	<u>1.312</u>	1.437	<u>1.334</u>
<i>D</i>	— .048	— .126	— .032	— .090	+ .016	— .077	+ .004	— .108

TABLE G.—Continued.

No. of Sittings.	McM.	W.	Ha.	M.	Mi.	Ma.	Hn.	Ca.	Average of last 10.
2 { <i>A</i>	1.301	1.350	1.408	1.372	1.425	1.029	1.183	1.268	1.306
<i>B</i>	1.163	1.210	1.397	1.474	1.322	.906	1.194	1.161	1.245
<i>D</i>	— .138	— .140	— .011	+ .102	— .103	— .123	+ .011	— .107	— .061
Totals, { <i>A</i>	1.301	1.350	1.408	1.372	1.425	1.029	1.183	1.268	1.306
<i>B</i>	1.163	1.210	1.397	1.474	1.322	.906	1.194	1.161	1.245
<i>D</i>	— .138	— .140	— .011	+ .102	— .103	— .123	.011	— .107	— .061

$$\text{General Average, } \left\{ \begin{array}{l} 1.277 \\ 1.213 \\ - .064 \end{array} \right.$$

Results: Total general average without practice, 1.2776
 Total general average after 6 min. practice on,
 .25, received only through left thumb and } 1.2137
 finger,

Total general average difference, —.0639

The results of these *G* experiments are particularly to be compared with those of Table *B*, both having had the same norm and same practice intervals. The length of time which practice was undergone, however, was in *G* double that in *B*, which probably should be counted as a reason why the difference between the “without practice” and the “with practice” results should have been greater in *G* than in *B*. An offset to this influence, however, lies probably in the fact that in the *B* practice the intervals were not only afferently received, but also efferently executed, bringing into play the whole psychophysical arc of sensory centers, motor centers, and muscles of the fore-arm, hand and fingers; under these circumstances this arc soon takes on, as a whole, a simultaneous function of a strongly reflex nature, the reproductions not following the beats of the norm, but precisely and spontaneously coinciding with them, beat on beat; the whole process of reproducing here is itself of the nature of an induced habit, and it is natural to suspect that the continuation of the habit, sustained through the term of practice, would have a stronger and more lasting

effect than where the sensory centers alone were exercised, as in the *G* experiments. What the precise results of these countervailing conditions may have been we cannot determine, but the very close equivalence of the total differences of the two tables ($-.0695$ for *B*, $-.0639$ for *G*), is very likely to have been within certain limits accidental.

It is not likely that the same experiments repeated under conditions as nearly as possible like these, and upon the same individuals, would produce precisely the same results, for the human organism, mental and physical, is so complex, its environment so variable, the entire conditions of the problem so multifariously changeable, that the mathematical probabilities are almost infinitely against identical combinations. But results constantly like in nature and approximately like in degree, should, we think, be deemed scientifically acceptable. Even with these, the time-problem is so difficult and so liable to subjective and delusive complications, that we cannot look upon the experiments here reported, (as extensive, careful and conclusive as we have endeavored to make them,) as being entirely conclusive until they shall have been confirmed by similar work of other experimenters. With these provisions, however, we think the results of the foregoing experiments indicate that, *sustained attention to a rhythmically repeated impulse induces in the corresponding nervous centre a habit or tendency to continue that impulse, which habit influences, or modifies succeeding time-judgments.*

The following table summarizes our results with reference to the Constant Error. We have thought best to give the length of the judgments rather than the amount of the error; the plus sign is prefixed to those judgments which are greater, and the minus signs to those which are less than their corresponding norm; also, the table shows the number of trials from which each average is calculated, and the table from which the same are taken. The judgments of Table *H* are alone the first series of each set or trial, that is, those made without practice or normally.

TABLE H.—CONSTANT ERROR.

Persons.	Norm .25		Norm .50		Norm .75		Norm 1.25		Norm 1.75	
	No. Trials and Table.	Average Judgment.	No. Trials and Table.	Average Judgment.	No. Trials and Table.	Average Judgment.	No. Trials and Table.	Average Judgment.	No. Trials and Table.	Average Judgment.
S.	10 C	— .249	3 E	+ .502	5 A 10 D Average	— .712 + .755 — .741	10 B 10 G Average	+1.435 +1.310 +1.373	3 F	+2.136
N.	10 C	— .239	3 E	— .480	1 A 10 D Average	+ .814 + .769 + .773	20 B 10 G Average	+1.335 —1.210 +1.293	3 F	+2.049
L.					3 A	— .607	3 B 5 G Average	—1.236 —1.061 —1.126		
C.					3 A	+ .750	9 B 5 G Average	+1.306 +1.347 +1.321		
H.	3 C	— .240			5 D	+ .818	5 G 3 B 5 G	+1.416 +1.291 +1.389		
A.					2 A	— .671	Average 2 B 1 G	+1.353 —1.142 +1.268		
Ca.	2 C	— .243			1 D	— .673	Average 2 B 1 G	—1.184 —1.242 —1.203		
Ma. Sh.	2 C	— .244			1 D	— .659	1 G	—1.029		
Mi.					1 D	— .740	2 B 2 B 1 G	—1.246 —1.203 +1.425		
F.					A	— .735	Average 3 B 3 B 1 B 1 G	+1.277 +1.506 —1.246 +1.441 +1.433		
W.							Average 1 G 2 B	+1.437 +1.442 +1.284		
D.										
B.	1 C	+ .250								
K.										
McD.	1 C	+ .250								
T.	1 C	+ .257								
Bl.					1 D	— .667				
McM.							1 G 1 G 1 G 1 G	+1.301 +1.350 +1.408 +1.372		
W.										
Ha.										
M.					1 D	— .725				
McA.							1 G	—1.183		
Hn.										
General Averages.	30 C	— .244	6 E	— .491	17 A 30 D Average	— .712 + .760 — .742	60 B 50 G Average	+1.322 +1.277 +1.302	6 F	+2.089

Results: With the method used, the experiments, on the whole, indicate that the judgments of intervals of .75, .50 and .25 are very slightly shortened, while those of 1.25 and 1.75 are considerably lengthened. Too few intervals were used to determine the Indifference Point accurately, yet in view of the great variations displayed, we may perhaps come as near the truth as can be well attained, if we calculate this point, for these experiments, from the General Average of the intervals used; according to such computation the Indifference Point would appear to be about .81. Yet so great are the individual differences and even the variations of the Constant Error from time to time for the same individual, that this error should be termed Inconstant rather than Constant, and as calculated from any number of persons yet experimented upon, must be considered as extremely problematical and uncertain. Particularly so, as we entirely lack any sure clue to its probable cause. In view of the indication arrived at, that the phenomenon is central, we might infer that the lengthening of the judgment was due to an inertia or tardiness of the centres to repeat the proper rhythm, and that this might be based upon a failure of response in nutritive processes; but this would be difficult to reconcile with the fact that the more rapid intervals, which would be supposed to exhaust the centres most quickly, display the opposite tendency and act more quickly than they ought. Or perhaps the relations between the nutritive and active functions of the centres, are an automatically compensating mechanism, wherein the supply is sometimes "over corrected" and again "under corrected" with reference to the exhaust, just as the balance wheel of a watch is often at fault with reference to temperature, and the watch varies with the season and with the pocket it is carried in; so the time-mechanism of the nervous centre may vary with individual and physical conditions, and with the coat we wear; surely the psychical time-piece is not less delicate or complex than its horological rival of human skill.

Comparing our own results with those of former experimenters, though we learn next to nothing of the cause of the Constant Error and too little of its course to predict

dict the same with any great probability, for any certain person or number of persons ; yet study of our tables, and still better of the original curves and charts too numerous to publish, reveals a few points of considerable certainty. Those individuals who make the largest constant error, make the error most constantly in one direction ; such persons, also, are apt to make a constantly increasing error throughout the series of reproductions of each drumful ; this phenomenon betrays itself even more conspicuously in the "after practice" series than in the "without practice" series ; the phenomenon is illustrated in the judgments of L and of H in Table G, and in their respective curves, Figures X and XI of the chart ; judgments of the former are unusually short throughout the experiments, and in the curves, show themselves growing rapidly shorter and shorter to the end of the drum ; the judgments of H are unusually long throughout all his trials, and his curves go rapidly up throughout each drum. This raises a serious question as to what the magnitude of the Constant Error would be for a longer and different period of reproduction. Possibly, also, this point has relation to the fact that contrary signs are found for the Constant Error by the German experimenters who used single reproductions, and by Mr. Stevens (with whom my results pretty closely agree) and myself, who used multiple reproductions. Examination of the first reproduction of each drumful of my work, does not discover the contrariness of sign for Constant Error, between the first and the subsequent judgments of the series, which would correspond to the contrariness of results between the above mentioned experiments with single and with multiple reproductions. New experiments seem needed for the tripartite relations between the sign of Constant Error, the number or length of time the norm is given as a sample, and the number of the reproduced judgments.

Another feature of interest is, that any slight nervousness or excitement of the subject shortens the judgments. Often the subject who sits for the first time, looks upon any psychological experiment as in some way a test of mental caliber ; this, together with fresh interest in the experiment, occasions a slight eagerness, excitement, or mental tension for the first

trial, which is not so much, if at all, present in future ones. Examination of results taken under such conditions, convinced me while the experiments were in progress that they were shorter than the ordinary ones. It is evident that this, if true, would have bearing upon the method of our experiments; for instance, if in first sittings the average judgments of the first or "without practice" trial be for the above reason shortened more than the following "after practice" set, allowance ought to be made for this in estimating the shortening or lengthening effect of the practice upon the later set; otherwise, in those cases where the practice interval was shorter than the norm, the shortening effect of the practice in the "after practice" set would be negated to the extent of the shortening due to excitement in the "without practice" set, and the reverse for practice intervals longer than the norm. Examination of the tables shows that the law, that the "after practice" sets are longer or shorter than the "without practice" sets, according as the practice interval is longer or shorter than the norm, is broken to a more or less degree in 48 out of 246 times; 17 out of these 48 digressions occurred in first sittings, and 11 out of these 17 occurred in those experiments where the practice interval was shorter than the norm. This is in accordance with what has been said regarding excitement, yet a more detailed scrutiny of the results than is possible to give here, is chiefly the ground for what we have stated on this point.

Much has been said by previous experimenters concerning the effects of attention. Undoubtedly with single reproductions sensibility and accuracy are directly proportional to the attention given; with multiple reproductions it is doubtful if this is the case for the expert and experienced subject. For myself, who have had very unusual experience, my best judgments are made by paying the greatest possible attention to the norm during the sample beats, and then, when the rhythm is once caught, abandoning myself to as near an unconscious or reflex condition as possible, letting the idea or habit of the rhythm run its own course undisturbed, as near as may be, by attention, volition, or any kind of thinking whatever.

Subjective opinions of one's own judgments; After finish-

ing each drumful the subject throughout the experiments was usually asked his opinion of how well he had kept his copy or norm ; only in a small and uncertain number of cases were these opinions found to agree with the truth, and frequently were directly contrary.

How long before the effect of practice shows itself as against the immediate memory of the norm ? The results are so variable that this question cannot be answered with precision ; nearly always the effect of the practice is exhibited in the very first reproduction to a marked degree ; before the expiration of 8 or 10 seconds the effect would seem to be in full force or tendency, from which time forth, the judgments where the Constant Error was well marked, gradually grew longer or shorter to the end of the drum, as we have before stated.

How long does the effect of practice last ? Our method did not permit us to observe a longer period than from 1.5 to 2 minutes ; the practice seemed to preserve its effect with nearly, if not entirely, its full force for that length of time.

Fatigue : A few experiments were made preserving closest possible attention to the beats and judgments for several hours at a sitting ; sample tests of the judgments were taken from time to time. So far as these go, fatigue could not be discovered to have any effect whatever.

Long Experience in making time judgments has been thought by Mehner and others to lessen the Constant Error. Study of the above experiments according to their dates on the protocol, which also agree with the order of the tables as published, discovers very uncertain evidence for this opinion, a slight probability perhaps inclining in its favor.

Mr. Stevens noticed in his work, that judgments of unusual length or shortness are apt to be corrected in the following judgment, "according to a standard which the mind carries, but to which the hand (or perhaps the will during the interval) cannot be accurately true." To a certain degree the same phenomenon is observed in my charts and curves, though I am rather inclined to carry back the cause to some automatically compensating adjustment of the rhythmic habit or

function of the nerve centres, than to the vague phrase "a standard carried by the mind."

Anomalies: Seeing no just reason for the culling out of anomalies in former experiments, I have permitted none in my own. Every test taken in the course of any regular experiment has been reported in its proper place, with the exception of a single trial each, for three persons, who, from nervousness (one was a young woman) or lack of rhythmic sense, were entirely unable to catch the beat of the norm in a way that would enable them to repeat it with any sort of regularity or likeness to the original.

Sensibility: Owing to the enormous labor that would be involved in computing the Average Error for so many judgments, no investigation was made by me of this factor. On the whole, however, I should say the nearly uniform results regarding sensibility of all former experimenters, which constitute almost their sole point of agreement, are entirely confirmed by the experiments here reported.

In closing this account of my experiments I have pleasure in thanking those who have given me so much valuable time, taken from their own University work, in acting as subjects for such a tedious and time-robbing investigation, and those also who have assisted me by suggestion, counsel and inspiration.

IV.—CONCLUSIONS.

Sensations and their images or reproductions have various attributes; qualitatively they are blue, or warm, or painful etc.; intensively they are strong or weak, bright or faint, etc. Duration, or continuation, is another attribute or characteristic of every sensation and of every image. This attribute is the ultimate and essential datum of time. Besides sensations and images, science infers and assumes the real and separate existence of certain physical elements, having fixed correlations with each other, and with sensations and images. Whether the grounds for this assumption are acceptable or not we need not here discuss; but according to this assumption, duration or continuing is also an attribute or characteristic of these physical elements, and therein forms a further

field of this ultimate and essential time datum. Again most philosophies, and, I think, all religions and all science, assert, infer, or assume the existence of some soul or super-psychical cause, as an ultimate element separate from, or as a further attribute additional to, the physical elements and the sensations and images; according to these grounds there is thus another field of this characteristic time datum. Thus our time datum is seen to be an attribute belonging to, and inherent in, everything that is conceived to exist. As such, also it is seen to be an ultimate datum; as much so as the blueness, the chilliness, or the painfulness of any sensation, or the existence of anything at all. Why things exist at all, or why their inherent nature is what it is, we think to be at present beyond human explanation. The fundamental datum of our present explanations, then, we shall state to be that time is this attribute of duration wherever it exists.

This being the nature of time, what constitutes a perception of time? Hoping the results will justify the use, we shall accept that nomenclature according to which it is said that every elementary sensation or image is *perceived* which presents itself in consciousness at all. When a sensation or image properly occupies the focus of attention, we shall say it is *apperceived*. According to this terminology, time is perceived whenever any sensation or image *durates*¹ in consciousness at all; it is apperceived when the duration properly occupies the focus of attention. Thus if we suppose a creature so simple as to be without memory, and capable from time to time of but a single elementary sensation of constant quality, say a pain, (such perhaps are some infusoria) we should say that pain was *perceived* whenever it occurred; we should not say it was *apperceived*. We should also say such a creature *perceived* time.

Why sensations ultimately differ at all, why some are red and some blue, some bright and some faint, or why some are long in duration and some short, is beyond explanation. That some are long and some short is an ultimate datum, and no more wonderful than that sensations are diverse in any other

¹I have coined this word, finding no other sufficiently simple in meaning.

way. But in the same way as we shall say of our simple creature, that he perceives his sensation when it exists at all, and that he perceives time when it (the sensation) durates at all, so we shall say he perceives a certain definite time when it durates in that certain definite manner. Its perception is its occurrence ; the ultimate nature of its occurrence, constitutes the ultimate nature of the perception ; the definiteness of its occurrence, of its inherent nature, constitutes the definiteness of that certain perception. We know nothing of the perception of such a creature except by inference and analogy ; but in the same way that we should say his sensation is painful, in that same way we should say one of his perceptions was five seconds long. And in the same way that we have said he perceives time when his sensation durates at all, so we shall say he perceives five seconds when it durates five seconds, and perceives one second when it durates one second. But according to this, one thing above all else must be carefully noted, *perception* or perception of time duration is *always a process and never a state ; a certain definite time is a certain definite process*. We can no more discover an explanation of our perception of the duration of five seconds alone in some mysterious momentary mental arrangement or "temporal sign," or other *instantaneous* characteristic, than we can discover redness in blueness ; for us to perceive blue, there must be blue ; for us to perceive duration, something must durate ; for us to perceive a definite blue, there must be a definite blue ; for us to perceive five seconds, something must durate five seconds ; for us really to *perceive* a year, some definite sensation would have to durate a year. What takes place when we say we have an *idea* of a year is another matter which we shall discuss in its place.

So also of series of sensations. That series occur at all is an ultimate fact or datum. What actually occurs when a series occurs we shall call a perception of a series. And in the same way as we can never perceive a half-second except something durate a half-second, so we can never perceive a series of five half seconds with intervals of half seconds between the terms, unless such a series occurs. When it occurs its entire occurrence will constitute its perception. Actually

to perceive such a series a year long, such a series would actually have to occur throughout a full year. What takes place when we have an idea of such a series we shall also discuss in its turn.

Neglecting for the present any consideration of the correlation between them, or of any perception of such a correlation, all that we have said regarding sensations applies as well to images or reproduced sensations ; really to imagine five seconds, some image must last five seconds ; fully to imagine a thousand clock-ticks, a thousand clock-tick images must pass through the mind. So also, fully to remember a thousand second-beats, a thousand second-beat images must pass in full mental review.

And as of pains, and clock-ticks, and second-beats, so of all other mental content whatsoever and however disparate. Mental process is mental perception ; every definite or certain process or procession is a definite and certain perception ; and every definite perception is also a definite time perception. Yet we must not forget that according to the nomenclature we are now using, perception is not apperception, and a definite time perception is by no means an apperception of a definite time ; this we shall come to later.

What we have said of perception applies as well to memory. But when we *say* we remember an occurrence, we seldom, and indeed never, except the occurrence is short, simple and of recent happening, remember it as accurately and fully as it actually transpired. That is, in its re-presentation in memory, some of the items drop out of the process, or rather fail to drop into it ; and the remainder stand *unsuspected* for the former whole—do so for the very reason that the former whole now is not, nor can be suspected at all, except in and through so much as *is* re-presented. I may have spent the whole of yesterday listening to the second beats of a clock, yet I may quickly remember that I did so, without the entire day and each tick repeating itself in full or in any instantaneous miniature of fullness in that quick remembrance. But in this quick remembrance, it is probable the entire mental procession of the previous day was re-presented alone by some momentary flash-picture, as it were, of myself as I was seated

at some particularly striking moment of yesterday, listening to the clock; perhaps this flash-picture or remembrance lasted long enough to take in no more than two represented ticks of the clock; perhaps to take in but one; or it may be that *all* the image-ticks were left out entirely and only the word "tick" or "clock" occupied their place in the quick remembrance; for such, it seems quite certain, is the nature of much of our thinking. If that in the above quick remembrance which occupies the place of, stands for, indicates, or symbolizes the original series be named the *idea* of that series, then the idea of that series is not a full representation of that series in any way. And it is plain also that we have in such an idea no such occurrence as that described by Herbart, or Mr. Ward, or any of those who conceive that an idea of a series, or of succession, or of time, must be some sort of instantaneously painted picture presenting the whole length of the time or of the series in a simultaneous perspective. Indeed if needed at all, there would seem to be needed as much such an instantaneous sidewise view of the duration of the simplest sensation and of the briefest part of time in order to perceive that it *durate* at all, as to perceive that it *durates* for, say, five seconds. The classic question therefore whether the idea of succession is or is not a succession of ideas, in so far as the question is one as to whether the idea is a longitudinally passing *process*, or a sidewise presented *state*, may as well be fought out with reference to the nature of any original sensation and for the briefest temporal portion of it, as with reference to any train or series of such sensations. Whether a sensation, an image, or a series of such, it does not matter; the pertinent question is, do we perceive the length of any duration, however long, by the *process* of that duration itself, or by some non-processional representative state? The chief arguments or suggestions I have been able to formulate or to find formulated for the "state" theory, all root, it seems to me, in the delusive catch-phrase, "We can not *now* perceive something that is *really past*, therefore our perception of past must be a *present* perception, *i. e.* a state." But this phrase is a series of verbal mis-statements and bad logic from beginning to end; we do not "*now*" perceive this some-

thing, whatever it is, but so far as I can discover we "now-now-now" perceive it; we do not stand still and look along the line to measure this past in a perspective view, but *run* along the line as it were (a new line representing the old) to measure it inch by inch, or present by present, by a moving process over again; nor is this something that we re-measure a "really past," nor in the absolute sense do we *re-measure* at all; but the "really past" and the original measuring both gone forever, a new representation of the gone past and a new measuring of the new representation happen "brand-new;" happen in original *representation* of them, though not in *re-representation* of them. All this being so, our phrase carried out in good logic should read "We *can not* 'now' perceive something that is really past, therefore our 'perception of past' must *not* be a present perception, *i. e.* must be a *process*. On the other hand, the evidence for the opposite or "process" explanation seems to me consistent and even positive. I think that every one who will observe his own mental process when he seeks to measure or to realize the length of any duration sensation or its representation in memory, will easily observe that he never fully perceives or remembers the length instantly or even approximately so; unless, of course, the duration is itself instantaneous or approximately so. On the other hand I think any one will easily convince himself that *fully* to perceive or to remember the length of its representations, these representations must stretch themselves out through an equal process and lapse of time as did their original occurrence. 'Quick ideas' of the nature described above may delusively flash upon us with approximate instantaneousness, but never a full and complete idea, and the time occupied by the idea will be proportional to its completeness.

Another evidence in favor of the process and against the "state" explanation lies, we think, in the following facts. The items of a long series, say the detailed events of a past hour, never are fully represented to us. It is easy to account for this according to the process theory; many of these details fail to reappear, and as the serial reappearance of those which do reappear is our sole suspicion of their presence, or of their order of appearance past or present, so of those which

fail to appear, we *at the time* have no suspicion of their absence or of the fact that they ever existed. At some other time we may remember further details, and also remember this abbreviated memory, and so become aware that we have dropped items from the latter. But according to the "state" theory, it is difficult to conceive why those causes which give the proper perspective to any part of a series where no items are gone, should not give the proper *perspective* to those items which do appear in a series when some items do not appear, and why such a perspective state would not have much such an aspect as the perspective of a picket-fence where some of the pickets are on and some off. Nor must we imagine such a conscious running-over of yesterday's incidents, as one in which we skip or jump from one incident to the other and almost feel the shocks occasioned by gaping items, to be just such a broken-fence perspective as we above describe. Surely such a series of shocks are a process and not a simultaneous state, even if we are conscious of the gaps ; but how we come to *be* conscious of the gaps in this running perspective, is a complex question entirely separate from the one under present consideration, and one we shall hope to throw light upon later. That we do not have simultaneous picket-fence perspective with pickets visibly off, that is with perspective gaps belonging to lost items, is quite evident in our attempts to recall the precise number of ticks in a given series just heard ; where as those who have had much experience must observe, they frequently with confidence think they recall the whole series perfectly and with no consciousness of gaps, though there are gaps.

We are inclined to conclude therefore that by the same process that we perceive the duration of any smallest part of any single sensation, by precisely the same nature of process we perceive the duration of any sensation however long and of any series however long ; that the duration of the sensation or series, the perception of the duration, and the perception of the length of the duration are one and identical ; that the duration is an ultimate datum, and no more capable or needful of other explanation or of further analysis than the blueness of a blue spot.

But perception of the length of a sensation, the apperception of its length, and the perception and apperception of its length as measured by some other sensation, are different matters altogether, as also are so-called perceptions of past, present, and future, and of other definite time relations, and of dates ; all of which we must now consider.

More often than otherwise those definite sensations which come through the focus of the eye are those which determine the immediately following ideas ; with great frequency these sensations definitely persist long enough to associate for some time with the ideas which they call up. With less frequency the definite sensations of hearing, touch, smell, and so on down the scale, determine the immediately following associations. Frequently very obscure sensations such as a red spot at the very edge of the field of vision, or the temperature of our teeth direct the association. Or perhaps as often as otherwise the particular mental group which determines the association is not a sensation or procession of sensations, but a definite group of images or procession of images which we may call an idea. Whatever group it is that determines the succeeding association, that group we say occupies the focus of attention, the terminology being evidently derived from the fact that the focus of vision is so frequently also the focus of apperception. Apperception is complete association ; the object of association is always the object of apperception, and the object of attention. The focus and the object are always identical. When we apperceive anything we couple it with its most usual associations, that is, memories of its own attributes, qualities, and characteristics. This kind of association *is* apperception. Time is apperceived when any process of duration occupies the focus of attention, is the object of association, and calls up durative associations ; that is, memories whose characteristics are particularly of the duration quality or nature.

We must with GREATEST care distinguish between perceiving time and apperceiving time relation.

Perceptions of relation are commonly supposed to be involved in the very core of the indissoluble mystery of the unity of the mind. We are deeply aware of the importance

of the subject, yet we have been driven to suspect that the secret of perceived relations is to be found in that they are associative processes of the apperceptive degree or nature and not simultaneous states. This subject is not our main question and we shall discuss it but in so far as is necessary for our explanation of time relations. If two tones precisely alike in quality, intensity, and length, begin precisely together and end together, no relation will be perceived between them. If one begins perceptibly before the other, relations will appear. Without some qualitative or some intensive *change* there can be no temporal *relation*. The occurrence of the change in the qualitative or intensive nature of the perception *is* the perception of the relation; and in the same way as it is not some necessary sidewise simultaneous perspective that constitutes perception of homogeneous duration, but the ever flowing attribute of duration itself, therefore we suspect, that every perception of temporal relation is fundamentally the actual procession of one term of definite quality or intensity followed without gap by another term of different quality or intensity; that actually to perceive any definite time relation or change, such must actually transpire; and fully to imagine or to remember such, the corresponding representation of it must again pass through the mind in full review. Without qualitative or intensive change no series could occur; such change is the essential characteristic of a series; the change *makes* the series. Fully to perceive the relations of the terms of a series the full series must be experienced either in original occurrence or in representation. To perceive that A B C D occurs in the relations a b c d it must occur in these relations. To perceive that B is after A, A must happen, then B. To perceive that A is before D, A must happen before D. To apperceive these relations is something quite different. To perceive that D is present and that A B C are gone, A B C must come and go and D must come; the apperceiving of the presence of D, or of the goneness of A B C, or of the relation of the presence of D to the goneness of A are other matters that need much elucidation.

To apperceive D it must occur, stand in the focus of the mind and call up images representing its qualities and usual

associations ; to apperceive it as *present*, it must call up the idea 'present' ; the apperceived relation of D to the Present is the occurrence of D followed by some idea of "the Present." For us to understand this relation we must understand "the idea of the Present." The word "present" is one that we associate with the continued presence of any mental content, or more strictly speaking with the durative procession of that content through the mind ; thus we can associate the word with a passing image as well as with a passing sensation ; but most commonly the word Present associates itself with the bodily group of *sensations* which we call self and with the environmental sensations which happen to be present at the moment that we are so apperceiving 'the Present.' Thus when we apperceive D as *present* the process that nearly always occurs is something as follows : first D itself, then the word "present," then some durating procession, most probably some sensation procession of our body or our surroundings at the particular moment. The length of this last associated durative procession is variable ; in quick apperceiving, as in quick remembering it may be little more than the word 'present' alone ; or it may be the quick flash of some mental duration even without the word "present."

But while on this subject we must not let words confuse several distinct data. Strictly the *perceived Present* is the content of any perception at the time of its occurrence ; is that occurrence itself. Similarly the *apperceived Present* is the occurring object of apperception ; that which directs the association. But to apperceive *the Present* that is, to apperceive the mental content actually occurring *as* the Present, that is again to perceive its *relation* to the Present, this occurring content must call up, and be associated with, the idea "Present" ; that is very likely with the word "present" followed by some durating procession very probable to be a continuation of the surrounding stream which was the object of apperception from the beginning ; in other words the apperception of the Present *as* the Present is usually but a sustained association of the word "present" with the progressive flow of the sensations within us or from around us. The *change* which reveals the relation, that is, the change which

constitutes the relation, in so far as a relation is a psychological occurrence, is the change occasioned by the dawning appearance of the associated idea.

So much for the Present, for apperceiving the Present as the Present, and for apperceiving D as present; now for the 'goneness' of A, B or C—the Past. Strictly speaking, mental content has no Past and no Future; they are only while they are, and their existence is like a mathematically moving point, or speaking of the total content, is like a plane moving at right angles to itself. What then is this moving procession by which, as we say, we have knowledge of the Past?

From what we have discovered regarding Present, we may suspect that perception of Past, perception of past relation or relationship, apperception of Past, and apperception of past relationship are all different matters. As the existence of any temporal portion of any mental content constitutes a perception of Present, so the *cessation* of its existence, constitutes a perception of Past. In order to perceive Past, some sensation or image must *cease*; whenever any such ceases, we perceive Past; the ceasing of the perception is the perception of Past; did no perception ever cease we should never perceive or know anything whatever regarding Past, or pastness, or about *the* Past.

To have a perception of past relation, a *relation*, that is, as we have explained, a *change*, must occur. To perceive a temporal *relation* between A and B, B must be different from A, and to perceive the relationship the relationship must occur; and we shall perceive whatever occurs, and we shall perceive it as it occurs, while it occurs, and in its occurrence; and we shall *only* perceive what occurs and while it occurs, and in its occurrence. To perceive A before B, A must occur and B succeed. To perceive B after A, A must occur and B succeed. The *perceptions* of the relation, A before B and B after A, are identical because the relationship A before B is the relationship B after A. The *apperceptions* described by these two phrases we shall discover may be quite different.

For an apperception of Past, the cessation of some sensation or image must call up some *idea* of Past, of something ceasing; striking or familiar examples, those which most for-

cibly impress memory, are those most *likely* to be called up ; yet the least possible fitting perception of something ceasing would suffice for the associated idea ; or even merely some word, such as " past," " gone," etc.

When we come to apperception of past relationships, we arrive upon confusing and difficult ground ; not because the essential and typical process is different from all other apperception, but because the associated ideas are so varied in number and kind, and our uses of language so loose and delusive. First we must note that an apperception of Past is not an apperception of past relationship. For example, A may occupy the focus of attention and its cessation call up associations of ideas of pastness. In this case B did not occur at all, and in the associations brought up, the pictures are of single terms ceasing. This is apperception of Past. But to apperceive any temporal *relation* A B, the change A B must occupy the focus of attention and its occurrence call up by association some *idea of relation* ; that is, some mental picture of change, some *a* followed by some *b*.

Our space will not allow us to analyse all the apperceptions of temporal relationships of past, nor is it necessary to do so ; a few important types will give the key to all. Perhaps the most crucial in the whole time problem is that which takes place, when, as we say, we perceive that something is *of* the Past ; a moment *ago* I knocked on my table so hard that it hurt ; I heard the knock and then felt the pain. What in my mental process constitutes this " ago " ? Clearly the " ago " is a relationship with some present. But what sort of relationship ? a perceived or an apperceived one ? And with *what* present ? Is it with " now-now-now-now " ? Or are we to speak of some particular " now," that " *now* " is not " now " at all, but as we shall see a mere idea of " now." When I felt the pain, I was not *thinking* about its time relations, that is I was not apperceiving such. I did *perceive* the time relation of the sound to the pain ; I did not *apperceive* it. It is quite possible that a representation of that sound may pop into my head again immediately after actually hearing a similar sound ; I shall then perceive a time relation between that representation and that sound, but I shall not necessarily ap-

perceive any time relation between them ; *whether I do or not will depend on whether the occurrence determines the subsequent current of association ; and the kind of relation that may be apperceived will depend upon the kind of associations that are called up.* Suppose I do hear a similar sound at some future time of my life, and by some favorable condition determined by my surroundings or thoughts at that time, a representation of the former sound and of all its surroundings at its time of occurrence be by association again brought into the focus of apperception ; that having thus sprung into mind *by* association they should then dominate and determine by association the next and following course of apperception and so on. What takes place here is a present sound like a former sound, followed by a representation that is like it and also like a former sound, followed in turn by a panoramic representation of that certain stretch of my past life that happened when I struck the table, heard the original sound, felt the pain and so on. Thus far there is in all this no apperceived “ago,” no apperceived time relation, merely this panoramic representation of the Past is passing through my mind ; I have not yet apperceived or, as we say in ordinary language, I have not yet *recognized* that it *is* the Past ; no least thought of the temporal *relation* of all this panorama nor of any part of it, not even of the represented knock, to the Present may have yet occurred to me. What shall we say so long as this panorama goes on and no direct time-relation to the Present is thought of? Shall we say all this is nothing but imagination? This question I think brings us to one of the most usual sources of confusion for our entire subject. Usually we *do* call just such panoramas as this memories, and remembrance, whether we do actually stamp their date upon them and think their “ago,” or their “how long ago” or not. The vast majority of the representations of those things which have happened but a moment or a few moments before, we have no need to date and do not date. The stream of thought or apperception into which they rise is not one regarding time relations or time characteristics, or time recognition. For instance, had I been writing an explanation of pain instead of time, the same panorama of the table, my

hand moving toward it, the thump, the pain, would have occurred as now when I write of time ; but from this point instead of a train of associations of time nature being set going, a train of pain relations would have been set going ; that is I should have apperceived pain and not time. The mere passage of past panoramas through the mind in no way constitutes a *recognition* that they are of the Past, or of how long they are past. Presently I shall show the difference between imagination and this sort of undated, unrecognized memory ; we are now examining dated memories, and we wish to know in what this dating consists over and above the mere passing picture. From what we have discovered, this should be comparatively well understood. First regarding the knock we may merely *think of it past*, without bringing in the Present or any particular time relation ; that is we may merely *apperceive it past* : in this case its image or representation will merely bring up in apperceptive process, ideas of Past ; the image of the thump will cease and ceasing images will follow ; perhaps the representation of the knock will continue to occupy the centre of the stage for some time, will continually go through the process of ceasing and of setting associated images to ceasing ; and for the time the whole play will be a regular variety performance of ceasing, while we may or may not be saying all the time or repeating all the while to ourselves the *words* ' past, past, past ' ; or ' thump past, ' ' thump past ' ; or if we had been less engrossed with the particular performers, any portion of it might have sufficed ; a single " tumble " or cessation of the first comedian Thump himself, followed by a tumble or two of the associated company ; or if even less engrossed, a mere glimpse of Thump followed by the word " past " would have completed the theatrical bill. This is the simplest form of apperception of the relation Past ; the *change* is that from the ceasing thump representation, to the associated ceasing representations ; the *pastness* lies in the relational change to the associated idea of ceasing, and this idea is composed of the associated ceasing representations.

Next we may apperceive that the thump happened *before* the pain ; here ' Thump then Pain, ' ' Thump then Pain ' will be the chief theatrical performance, in imitation of the origi-

nal actual occurrence; if we are not in a critical mood this pantomime may suffice even without the word "before"; the *repetition* of the main performance may constitute the idea; or if we are more reflective and exacting, the whole company may be called out, and the whole stage be set whirling with mimic and peek-a-boo representations of 'beforeness.'

The "show," for apperception of the fact that the pain happened *after* the thump, would differ little from the last above. Pain here would come on to the stage first, making the bow, as it were, that introduces the "show," instead of Thump, as previously, and he will probably make an extra bow between each alternating bout between him and Thump, just to make sure that we keep our eye mainly on him; and every time he makes such a bow he (or we) will say "after," or to speak more soberly, the word "after" will say itself by association, instead of the word "before" saying itself.

The play by which this Thump-Pain representation is apperceived, *i. e.* thought of in relation to the moving Present, may now be easily understood; we here no longer look alone at the stage, but we take in the whole view around us, from our body outward and, as well, from our body inward. Thump-Pain are the chief actors on *the inner stage* as before; they are the *first* objects of apperception from which the course of thoughts wanders momentarily down among the audience, that is to our actual 'now-now-now' surroundings, and inward to our own bodily sensations and even to attention to our own thoughts; but now and anon our focus of attention flits back from these actual Presents to the show 'Thump-Pain,' again viewed on the mimic stage of memory. And as we have said of simple apperception of Past, so of this process of apperception of 'having happened before the Present.' Here the play may be longer or shorter according as we are more or less reflective; a twinge of neuralgia may suffice for the moving Present, with or even without the word "present" or "now"; and a single bow from Thump or Pain, that is a single memory image of these may suffice for their remembrance, or there may follow a full apperception of 'Thump-Pain past,' that is of the *ceasing* of the thump and of the pain, as described above.

We have now described what takes place when, as we say, we think of a thing or event as past, and when, as we say, we think of something as *of* the Past; that is, past with reference to the moving present. But particular time-relations, such as yesterday, last week, a year ago, ten minutes since, remain to be discussed. But as this brings up the subject of *measured* time, let us postpone these for a word concerning so-called perceptions of Future. As the fundamental sign of every idea of Present is the *continuation*, and that of every idea of Past is the *cessation* of some representing image, so the fundamental sign or characteristic of every idea of the Future is the *beginning* of the representing associated images. When I think of the Future of things, I think of them as *beginning*. As I go over a familiar way, memories of the path ahead of me beyond my view keep *rising* in my mind and constitute the foundation of expectation. If I apperceive these expectations, as expectations, the associations are those of the *act* of expectation, plus the panoramas of the path. In this case, *I* enter into the "show," the whole moving action of my bodily feelings while I sit here or walk there and expect; that is, certain holdings of the head, wrinkling of the brows, laying my finger to my chin, or the like; meanwhile the stage show goes on, the performances now being emphatically those of the "beginning" nature or plot, together with little mimic side pantomimes of myself in the acts and experiences of expecting; also the orchestra plays "future" "future" the while, or anon, plays "expectation" "expectation," and the panorama of the path ahead of me moves on in ever beginning glimpses. Apperception of Future, and apperception of *the* future, are similar to the apperception of expectation, and, I think, need no further explanation than may be derived from the above.

But how do we *measure* time length, and measure "how long ago," and "how long until?" When speaking of our simple creature capable of but a single constant sensation, we said that when his pain lasted five seconds, he perceived the length of five seconds, and when it lasted one second, he perceived the length of one second. We distinctly declared he did not apperceive either length, and from what we have said

of change and relations it is clear that I have not conceived that this creature perceived relations of any kind; neither relation of difference nor of number. Here we must be most careful not to let our customary use of language and our common processes of thought designated by common language, confuse us as to the actual elementary processes of mind which we never experience singly, and for which consequently we have no common or definite designations; and, what is more usual, have no definite or apperceived conceptions. Until some one opened our understanding to the matter, we went on deludedly imagining that we saw distance through rod-and-cone processes, the same as we did blueness; now we discover that what we call *seeing* distance is chiefly not seeing at all. It is probably the same with all the ultimate elements of sensation; Prof. Wundt reminds us that we never experience them singly, and so with great difficulty arrive at any conception of what each or any one element singly of itself is like, or what its various attributes are like. We should be prepared therefore to comprehend, since apperception of length and of number is not perception of length or of number, and again since perception of *difference* of length, and difference of number, (these all involving changes and relations) are not mere plain perception of length and perception of number, we should, we repeat, yet be prepared to comprehend that perception of five-seconds length is not in ultimate nature the same as perception of one second length. That there is a difference here, we think it comparatively easy to demonstrate, though it is quite certain that we do not ordinarily apperceive the difference, that is, do not form and associate ideas of it with its occurrence. It is probable, in our ordinary apperceptions of time length, that the associated *ideas of length*, which make up the apperception, are those representations or memories of muscular tensions, dermal stretchings or joint pullings, which fundamentally are the components of our ideas of motion; consequently has perception of time been so commonly founded on perception of motion, from Aristotle down to present psychology. There is little doubt that the intensive changes, which are the characteristics of these motion sensations, are the striking and

characteristic components of those associated ideas which enter into our ordinary apperceptions of time length. But we must not fail to note that these changes are not the only components of these ideas, and that these image processions, and also their prototype original processions, are not *all* change; there must be duration without change in order for duration with change to be possible. And in the same way that we continually *perceive* changes different in degree of change, without *apperceiving* any difference, so it is probable, and I think certain, that we continually perceive durations of different lengths without apperceiving their difference. For example, of our simple creature I think one should now have no difficulty in conceiving how there might and would be a difference between his perception of a five-second pain and his subsequent perception of a one-second pain, and yet this creature never perceive the difference; that is, might not have any relational idea of such a change, as we might find to constitute the process of perceiving or apperceiving *difference*.

Prepared, therefore, not to confound actual difference with perception of difference, let us examine these matters more closely. We found that duration and change are ultimate data; we shall also discover that differences of duration are also ultimate facts. We shall never discover why ultimately these differences are differences, but given these differences, we shall discover, I think, how we come to perceive, and finally to apperceive, these differences, and in what these processes consist. Carefully considering the matter in the light of the experiments reported in Chapter III, I have been led to suspect that this perception and apperception of durative differences may rise in two ways, which, for convenience, I shall here designate as the single method, and as the multiple method. These experiments emphasized the fact long before determined, that our so-called memory images are dependent upon certain reproductive *habit* processes of our nervous and bodily organism. Were it not for these "habits" we should have no memory. My experiments emphasized *the degree to which the validity of correlation between these so-called memories and their originals, depends upon the validity of these organic habit processes*. If the habit is not accurate,

the memory will not be faithful, *although we shall not have the least suspicion that it is not faithful*. The truth is, the memory may be altogether different in temporal length from the original temporal length without our perceiving or recognizing their difference, or suspecting anything about such a difference whatever. Nothing can bring out more clearly than this, that *actual* difference does not constitute recognition of difference, and that perception and apperception and recognition of difference are all some sort of processes quite different from and additional to mere actual difference of occurrence. *To apperceive these differences, they must, by association, bring up certain qualitative ideas and ideas of difference.*

We do not yet know positively the particular portion of the brain organism, whose rhythmic reiterative habits are chiefly responsible for memory ; it is sufficient, however, for our present purposes that it is *some* particular portion of nerve organization, which, for convenience, I shall here designate in accordance with present probabilities, as the central nerve cells. My experiments demonstrate that when these cells functionate with reiterative temporal accuracy, our time judgments are accurate, and as their habit varies or is disturbed, our judgments vary correspondingly. We have also to observe how frequency and lateness of original occurrence form and influence this iterative habit. We have then to note, that immediately after the occurrence of a definite sensation, which previously has been frequently repeated, say the tick of a metronome, two forces, or to speak more accurately, the tendencies of two processes, are contending against each other in the production of the succeeding memories ; and, indeed, as well in the production of the succeeding *sensations* themselves. The cells, both those which functionate the memories and those which functionate the tick sensation, (be they the same or not, we do not know) tend on the one hand to follow the rhythm to which they have previously been trained, tuned or accustomed, and on the other hand, to adopt a new rhythm in correspondence to the rhythmic impulse then and there received from the metronome. Not only, therefore, is the result likely to be ever a compromise between the two, and our sensations at different times and under various conditions, likely to vary

from the actual metronome rhythm and from each other, but quite possibly another result of more peculiar nature may also happen from and during this contention of tendencies. For instance, suppose the metronome to be beating quarter seconds and the cells to have been tuned or adjusted by preceding practice according to the method of our experiments to second beats. Plainly by the law of association and habit, the first stroke of the metronome sets going the tendency of the cells to perform their second-beat representations; and consequently the impulses sent in from the succeeding second, third and fourth beats of the metronome will find the cells in a different condition than did the first beat. Precisely what would be the nature of the result of this contention or disturbance of the regular order of things, or what the difference between this and the case where the old habits of the cells should be entirely overcome by the new influence, or where the cells from the beginning were accurately adjusted to the beat coming from the metronome, is difficult to say. It is well to note, however, that this condition of contention between new and old influences or habits is the usual condition rather than the exception; and that any peculiarity of sensation or feeling which should result, as is very likely to result from such a struggle, might be a very important factor in time measurement. Not that such a peculiarity or temporal sign would of itself alone constitute *apperception* of time length, but reproduced representations, or repetitions of these different temporal signs among the associations constituting the apperceptive after-train of ideas called up by *actual* time differences, may be definite and determining data in such apperceptions of different time lengths. And in consequence of these contentions also, and of apperceptions which they determine, it is quite possible that in the *original occurrence* of familiar sensations we may have indefinite cognizance of "too short" or "too long" *without definite memory or apperception of that in relation to which it is short or long*; it is quite possible that these definite memories sometimes are and sometimes are not then called up by these apperceived signs. In short, during the original occurrence of a series we may, as it were, apperceive a general abstract definiteness of length or of time difference or

relation, without its being followed by concrete definiteness ; that is, we may apperceive that it is definite without apperceiving its full definiteness, for such subtle tricks are, by no means, psychically uncommon. Should that which we have tried to describe be true, those theories which have sought to explain time relations and time perceptions by "temporal signs" or a disparate sense would have herein some foundation of analogy.

But more frequently perhaps are the rudiments of time measurements to be discovered in a method different from the above. Should an image occur simultaneously with its corresponding sensation, the two beginning and ending precisely together, this equality of their length, would, in accordance with our foregoing nomenclature, constitute the perception of their equal length. Without fuller description, we may understand how by association this perception would rise to apperception, and thence to apperception of their temporal equality. Similarly, if the image and sensation were of unequal length, we may comprehend how this would rise to apperception of their inequality. Again, if equal temporal series of simultaneous sensations and memories, or yet again, unequal temporal series of such, occur, we may also prefigure how these get apperceived, and what will constitute the nature of such apperceptive processes. But before we speak finally of such processes, a word must be said as to apperception of number, in order fully to elucidate how we apperceive a sensation to denote *so many units*, or to be so many times longer than another.

For four sensations to be perceived, four sensations must occur ; for these to be apperceived, the idea of four, *i. e.*, the word "four," or some four image reproductions, or both the word and the four reproductions must be added in proper apperceptive process thereto. So of any other number of sensations or images. This is the key to the simple apperception of number. A sensation, four seconds long, may occur succeeded by four different sensations, each one second long ; by our first method of measuring time length, combined with the apperceptive process of number, we may understand how we arrive at an apperception of one sensation being four times the length of another. Or a sensation four seconds long may occur

simultaneously with four sensations, each one second long; and so by the second method of time measurement, combined with the apperceptive process of number, these would rise to apperception of the one as four times the length of the other. And so on with other multiple number-measureings.

Before leaving finally this subject of habit rhythm and time measurement, a word more regarding those theories which have found in our main unconscious bodily rhythms, such as breathing, pulse-beat, and leg-swing, standard rhythmic measures of our time judgments. We have pointed out as objections to these theories, that we have no reason to conceive why one such unconscious process should dominate as a standard more than any other; yet for all to contribute such unconscious disturbances would, indeed, so we must think, lead rather to indiscriminate confusion, than to standard discrimination; such views, moreover, run quite contrary to the selective advantages of unconscious reflex actions, which, by relieving consciousness of all such disturbing vital processes, have made our conscious processes distinct and intelligible. Also we have mentioned that, according to the theories of breathing standards and the like, it would seem that we ought to have a more lively and accurate conception of the definite length of such processes as breathing than of any other duration lengths or rhythms, while, as a notorious fact, we do not; but rather those rhythms which we most customarily hear are those which most vividly rise up with accuracy and as standards. This brings us to the point on which we wish to lay further emphasis; and for this we would note that the particular function, to which our conscious centres seem to be differentiated in contradistinction from the reflex unconscious centres upon which our vital processes depend, lies in just their power and tendency to *adapt* themselves to the multitudinously time varied outer impulses to which consciousness is to correspond, and whose purpose it is to represent; their very peculiarity consists in differentiation to outward susceptibility rather than like the unconscious reflex vital nerve centres to a particular inward rhythm approximately undisturbed by outer influences. Nor must the fact shown by our experiments, that unusual frequency of repetition by the *conscious* cells of im-

pulses received from without tends to perpetuate such particular time rhythms or habits to the temporary detriment of accurate judgments of other rhythms or time lengths received from without, be counted against this view, but rather for it; for if there were *no* tendency for these conscious cells accurately to reserve their habit of repeating the occurrences from the outside, which were their original prototypes, there would never be any accurate time memories or images of our sensations at all, in fact, no rational memory whatever. The whole cerebral and central nervous organism seems a happy adjustment of fixity of habit, not too fixed, and susceptibility, not too susceptible. There would seem reason from *à priori* grounds to suspect, therefore, that which from observation seems to be the case, that our standards of time-measurements are memories of certain most striking rhythmic, habit-inducing, and oft-occurring outer occurrences, such as the particular length of watch or clock ticks, which we are most accustomed to hear; the sounding-hours; the varying lights and shadows of morning, noon and night; the peculiar Sundayness of Sunday and Mondayness of Monday; the varying seasons; perhaps also as we have surmised vague temporal signs or admonitions of passing moments and as well of passing years.

After all the foregoing, it seems unnecessary particularly to explain apperception of such time relations as "yesterday," "to-morrow," "last week," "a week hence," "a year ago," or "ten minutes ago;" these terms are but particular words associated with particular time occurrences and number measurements, which rise into more or less extended and definite processes of apperception of such relations, according to our reflectiveness of mood or passing mental circumstances.

We have seen that much of our thinking is comprised of image-trains representing past occurrences to which we attach no date; which we do not think of or apperceive as of the Past at all; that is, which we do not actually *recognize* as of the Past or as ever having been seen before. We have to repeat that in our belief some of the chief confusions of psychology, and as well of philosophy, come from commonly mistaking this mere passage before us of trains that *are* correspondent

to former trains for those mental processes which do properly constitute psychological recognition. It is curious to note that those metaphysicians and psychologists, who most stickle against the possibility of any *real* recognition of any non-psychical *real* world, most unsuspiciously build their systems upon fancied *real* recognitions of past sensations in so-called present representations of such. The truth is that in the absolute sense we do not any more recognize sensations in their image representations than we recognize real things in their sensational representations. Until it dawned upon the human mind that its former so-called recognitions of an outer world could all be explained without the real existence of such a world, no one suspected the *reality* and *validity* of these recognitions ; we now all admit such so-called recognitions to be but psychic processes ; the *validity* of these processes and recognitions is, and we think must for a long time be, a subject of debate. We here wish only to point out that these parallel recognitions, so-called, of former sensations are likewise but psychic processes, the validity of which is as much open to suspicion, as inferred and as hypothetical as that of the so-called recognitions of a real world, and, indeed, vastly more so ; for how commonly are our most confident memories mistaken, and our insane and hypnotic subjects engulfed in hallucination.

Still more is this truth forced upon us when we comprehend the details of these processes of so-called recognition ; when we clearly understand the psychological difference between imagination and so-called recognition. If every one of us through life were but rational every alternate minute and insane turn and turn about every other minute, there would be no difference between imagination and reality. The grounds for our present belief in some real difference lies in the constancy of our belief itself, and when we come to examine into it, we find this belief is a hypothesis, an inference, and no *positive* knowledge. But what then are the grounds for this hypothesis ? Plainly not in any simple direct cognitive act or state. We have sure reason to believe that our ordinary so-called perception of time relation is not a peculiar disparate state, but an apperceptive process ; and similar analysis, I think, discloses to us that recognition is a similar appercep-

tive process, and that imagination is still another such a process. The difference between imagination and recognition lies first in a marked difference in the character of the thoughts which form the objective process of the apperceptions, that is, to which the associated ideas are added in the two cases ; and, secondly, in the character of these *added* or associated ideas or processes. And as it is the nature of apperceived associations to be of like character to the objects of apperception, we shall find that the difference between the associated ideas in our two cases corresponds in characteristics to the original difference between the objective processes themselves. What then is this fundamental difference between imagination and reality? We can only answer with an hypothesis, and this hypothesis is, that all things *do* occur in a fixed order, that all occurrence *is* a fixed order; that not all this occurrence is perceived by us ; that certain of the total occurrences of the universe result in fixed and definite influences upon our brain organism ; that like causes produce like results ; that like stimulations produce like sensations ; that like series of stimulations are followed by like series of sensations ; that these physical stimulations *are* alike and these corresponding sensations *are* alike, though the mere occurrence of their likeness by no means constitutes our recognition of this likeness ; that owing to the peculiar nature of our physical organism and particularly of our central nervous organism, whereby physical processes tend to repeat themselves, certain representations or repetitions of sensations corresponding to these processes in certain characteristics *do* tend to occur whenever these physical processes *do* repeat themselves ; that the accuracy and scope of complexity of temporal correspondence between these representative processes and their originals depends entirely upon the habit validity of these physical reiterative processes ; that our recognition of this validity and correspondence does not consist in some super-added cognitive act over and above those psychic processes which correspond to these reiterated physical processes, *but is entirely dependent upon, and to be explained by, a hypothetically actual correspondence or likeness of these reiterative processes, both phy-*

sical and psychical, to former processes, physical and psychical; finally, and again, that not even the mere validity of this correspondence alone comprises "recognition," but that recognition is a psychological process, the validity of which rests upon the validity of such correspondence. Our hypothesis is that the events of our lives do happen in a single definite actual order, which so impresses itself upon our memory organism, that by proper associative incitement, this order tends actually to be repeated. It is true that this same memory organism, lacking these major associative incitements, forms secondary associations, and these tertiary, and so on almost to infinity; and in proportion to the frequency in which these minor associations occur, and in proportion to their kinship to original occurrences, do they also tend to rise in association processes. These minor and less constant associations are the basis of imagination; "imagination" is a word which we associate with these *inconstant* flights of association; "reality," "actual," are words we associate with the main *constantly* reappearing stream of association. The fundamental difference between imagination and recognition lies in the fact that the iterative habit of our nervous organism is so susceptible to original *outer* influences and so accurate and persistent in repeating these, that they ever *do* remain a comparatively unbroken series in representation, while those series which happen not by any outward actual order of incitement, but by secondary associations of portions of those primary series, do *not* persist in like unbroken representation. If, by any chance, a new link can be fastened into the original or actual memory order with the same associative firmness and strength as an actual occurrence would have been, then such will actually appear to be recognized as actually having occurred and psychologically will be so "recognized." Liars who frequently, actively and consistently enough practice their imaginary associations, do eventually arrive at such psychological "recognitions;" all of us at times suffer such hallucinatory remembrances, and actually believe we did so, or so, or that such and such happened, when, actually, they did not; and the hallucinations of the insane and the hypnotic are

confirmative of our hypothesis. Imagination is inconstant memory ; remembrance is constant memory. As we have said both these processes commonly go on without conscious recognition of the fact that we *are imagining* or *are recognizing*. When these last processes occur, simply the bodily act rises to the focus of apperception ; and in apperceiving the "act of imagination," imaginative ideas, that is, inconstant memories are called up and flit before the mind ; while in apperception of the "act of recognition," portions of the constant train of memory are called up to constitute the apperceptive association.

Let us summarize the foregoing : Our simple creature received series of like sensations, but he did not recognize them to be alike. So we, if incapable of memory, should experience often repeated sensations, but should never recognize them to be the same. Even, if endowed with memory, we should never recognize a constant actual series of life's events, did not life's events happen in a single definite order. Our actual remembrances are representations which *do* follow the actual order of original events. Our imaginations are representations which *do not* follow the original order. The validity of our imaginations and of our recognitions, depend alike and absolutely upon the degree of faithfulness with which the neural processes which produce them correspond to the neural processes which produced the original psychic events.

Briefly stated, the final result of this protracted investigation of the time problem is as follows :

The general consensus of past and of current opinion is that time perception must alone be accounted for within some peculiar simultaneous psychic state, and, according to most authors, by some peculiar and disparate form of consciousness, in addition to our stream of ordinary sensations and their representative images.

The conclusion which we offer is that the processes of our environment, of our bodily organism, and of the sensations and images which correspond thereto, are, in themselves, within the limits of the insoluble mystery of the existence of

any physical or psychical existence at all, a sufficient explanation of time-psychology, and that time perception cannot be explained by any single state or disparate sense, but can alone be accounted for as a *process*. The bearing of the experiments of Section III upon these conclusions, and of the conclusions upon the experiments is obvious. The author is conscious that neither the one nor the other exhausts the topic, and will be content if they draw closer attention and study to the *habit relations* between neural and psychic PROCESSES.

Approved as a Thesis for the Degree of Doctor of Philosophy in Psychology at Clark University.

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